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(54) HARD COATING ULTRAHIGH TEMPERATURE HIGH PRESSURE SINTERED MATERIAL

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a hard coating sintered material used for cutting tools, etc., with improved adhesion of hard coating and adjacent material.

SOLUTION: This is the hard coating ultrahigh temperature high pressure sintered material consisting of coated base material of ultrahigh temperature high pressure sintered material containing cubic system boron nitride and/or diamond and its coating containing hard coating of one kind of single layer or multi layers of more than two kinds chosen among Ti compounds layers and Ti-Al compounds layers and its coating consisting of cubic system crystal structure. Regarding the hard coating, when an X-ray diffraction is carried out on the indicated range of crystal faces (111), (200), (220), and (311) of the hard coating, (200) crystal face shall show the highest peak strength (shown as 'A') of X-ray diffraction peaks and shall have the relation of $A/B \geq 8.5$ against the second highest peak strength (shown as 'B') and the relation of $B/C \leq 2.0$ between B and the third highest peak (shown as 'C').

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the hard film covering super-elevated-temperature high-pressure sintered compact with which the coat containing the hard film which comes by the monolayer of Ti compound layer and/or a Ti-aluminum content compound layer or the multilayer on the base material of the super-elevated-temperature high-pressure sintered compact containing cubic boron nitride and/or a diamond was covered.

[0002]

[Description of the Prior Art] The super-elevated-temperature high-pressure sintered compact which sintered from the former the diamond which is the super-high degree-of-hardness matter, the powder of cubic boron nitride and a metal, and/or mixed powder with the powder of the ceramics with super-elevated-temperature high pressure installation is used. This super-elevated-temperature high-pressure sintered compact is used as a base material, and the hard film covering sintered compact which covered the hard film on this base material using chemical vapor deposition (henceforth a "CVD method"), physical vapor deposition (henceforth "PVD"), or a plasma-CVD method is proposed. JP,59-8679,A, JP,61-183187,A, JP,1-96083,A, JP,1-96084,A, and JP,7-24606,A are one of the typical things of this hard film covering sintered compact.

[0003] Moreover, cemented carbide, the sintered alloy of a cermet, or a ceramic sintered compact is used as a base material from the former, and it has used with gestalten with the various covering sintering member which covered the hard film on this base material using a CVD method, PVD, or a plasma-CVD method. Although the crystal structure of the hard film was observed among these covering sintering members, to a typical thing JP,52-28478,A, JP,8-209335,A, a publication-number No. 291353 official report, JP,9-295204,A, JP,9-300105,A, JP,9-300106,A, JP,9-323204,A, JP,9-323205,A, JP,10-76407,A, There are JP,10-76408,A, JP,11-1762,A, JP,11-131214,A, JP,11-131215,A, JP,11-131216,A, and JP,11-131217,A.

[0004]

[Problem(s) to be Solved by the Invention] Among the bibliographies mentioned as a conventional technique, the super-elevated-temperature high-pressure sintered compact which mainly contained cubic boron nitride is used as a base material, and the hard film covering sintered compact which covered hard film, such as carbide of Ti, a nitride, carbon nitride, and an aluminum oxide, on this base material front face at the monolayer or the multilayer is indicated by JP,59-8679,A, JP,61-183187,A, JP,1-96083,A, JP,1-96084,A, and JP,7-24606,A. The hard film covering sintered compact of an indication in this official report of these five affairs may be characterized [main] by the base material presentation component of a sintered compact, when characterized [main] by the configuration of the hard film which becomes by the monolayer or the multilayer when characterized [main] by the membranous quality of the hard film. Although it is thought that the hard film covering sintered compact of an indication is uniting with the official report of these five affairs apparently the effectiveness which was excellent in the base material itself, and the effectiveness which was excellent in the hard film itself,

since it is not especially considered about the compatibility of a base material and the hard film, there is a problem of becoming a short life by exfoliation of the hard film. Moreover, it stems from an ecology problem like recent years, and a saving-resources problem. As opposed to the cutting tool suitable for a demand of commercial scenes, such as the optimal cutting tool accompanying diversification including the material change of the tool for dry cutting cut without using cutting oil, and **ed material etc., further high-speed-cutting conditions, heavy load cutting conditions, and high efficiency cutting conditions, etc. The hard film covering sintering object of an indication in the official report of said 5 affairs has the problem that the inclination which becomes a short life with lack of the ease of exfoliating of the hard film or thermal resistance, and thermal shock resistance etc. is high.

[0005] JP,52-28478,A, JP,8-209335,A which were mentioned as other bibliographies, A publication-number No. 291353 official report, JP,9-295204,A, JP,9-300105,A, JP,9-300106,A, JP,9-323204,A, JP,9-323205,A, JP,10-76407,A, JP,10-76408,A, JP,11-1762,A, To JP,11-131214,A, JP,11-131215,A, JP,11-131216,A, and JP,11-131217,A Cemented carbide, the sintered alloy of a cermet, or a ceramic sintered compact is used as a base material. The compound nitride which contains a periodic-table 4a group's carbide, nitride, carbon nitride and titanium, and aluminum on this base material, The covering sintering member with which the hard film of compound carbide, compound carbonitride, a compound nitric oxide, a compound carbonation object, and the Ti-aluminum content compound that becomes by the compound charcoal nitric oxide was covered is indicated.

[0006] The covering sintering member of an indication in this official report of these 15 affairs is characterized by carrying out orientation of the hard film on the front face of a base material mainly to various gestalten. In this official report of these 15 affairs, when the residual compression stress in the hard film is being taken into consideration, the crystal orientation in the hard film may be taken into consideration, and control of the intergranular fracture in the hard film, improvement in the adhesion of a base material and the hard film, wear-resistant improvement, stable cutting, or long lasting achievement is indicated as the effectiveness. However, the covering sintering member of an indication in this official report of these 15 affairs From the defect of a crystal and distortion which exist in the hard film not being considered, and not being especially considered about the compatibility of a base material and the hard film Cannot be satisfied with adhesion with other film contiguous to the adhesion and the hard film of a base material and the hard film. By the time it also satisfies the reinforcement of the hard film itself, and abrasion resistance, it will not result, but the variation in a life is large and there is a problem of mainly becoming a short life with lack of the ease of exfoliation of the hard film or thermal resistance, thermal shock resistance, etc., to a demand of a commercial scene which was mentioned above when it used as a cutting tool.

[0007] This invention is what solved the above troubles. Specifically By mainly considering the defect, distortion, the crystal structure, and crystal orientation of the crystal of the crystal structure-compatibility of the base material of a super-elevated-temperature high-pressure sintered compact, and the hard film which adjoins this base material and is covered, and the hard film Raise the adhesion of a base material and the hard film extremely, and the variation in the property of the hard film is controlled. It considers as the hard film with high toughness, high degree-of-hardness nature, abrasion resistance, oxidation resistance, thermal shock resistance, defect resistance, and joining-proof nature. The use field as a cutting tool is expanded and it aims at offer of the hard film covering super-elevated-temperature high-pressure sintered compact which made the longevity life attain further by considering as the hard film which raised joining-proof nature with **ed material.

[0008]

[Means for Solving the Problem] this invention person used to acquire the knowledge that there is optimal hard film configuration, when making the front face of the base material which becomes with the super-elevated-temperature high-pressure sintered compact containing cubic boron nitride and/or a diamond as a result of continuing at a long period of time and having done research on membrane formation of the hard film about a CVD method, PVD, and plasma PVD, especially research on the hard film by PVD cover the hard film which becomes in Ti compound layer and/or a Ti-aluminum content compound layer. If it changes into the condition of performing improvement in the plasma consistency

at the time of membrane formation of the hard film, and improvement in ionization efficiency, and carrying out gaseous-phase method epitaxial growth further if this knowledge is explained concretely. The defect of the crystal of the hard film is controlled [that the distortion in the hard film is eased by homogeneity,], From that the hard film of a fine crystal is obtained, and becoming the hard film of the crystal which is not seen and which changed orientation into the optimal condition extremely at the former. The 1st knowledge that become possible to raise the reinforcement, the abrasion resistance, the oxidation resistance, and thermal resistance of the hard film itself, and improvement in the adhesion of the hard film and a base material becomes remarkable. When the X diffraction of the orientation condition of the crystal of the hard film is carried out from the front face of the hard film, its 2nd knowledge that it can judge when the peak intensity of the crystal face becomes extremely high to other crystal faces (200) in the hard film is main. Based on these knowledge, it comes to complete this invention.

[0009] The coat is covered by the front face of a base material on which the hard film covering super-elevated-temperature high-pressure sintered compact of this invention becomes with the super-elevated-temperature high-pressure sintered compact containing cubic boron nitride and/or a diamond. This coat Ti compound layer which becomes by the carbide of titanium, a nitride, carbon nitride, the carbonation object, the nitric oxide, and the charcoal nitric oxide, And the compound nitride containing titanium and aluminum, compound carbide, compound carbonitride, It has one sort of monolayers or two or more sorts of multilayer hard film which were chosen from the Ti-aluminum content compound layers which become by the compound nitric oxide, the compound carbonation object, and the compound charcoal nitric oxide. This hard film that adjoins this base material and is covered consists of the cubic crystal structure, and a copper target is used from the front face of this hard film. (111) of this hard film, and (200) -- when the X diffraction of the range where the crystal face is displayed is carried out, and (220) (311) The crystal face (200) shows high peak intensity (it expresses "A") to the 1st in an X diffraction peak. The ratio of high peak intensity becomes the 1st or more from 8.5 ($A/B \geq 8.5$). peak intensity (it expresses "B") high to the 2nd is received -- this -- and peak intensity (it expresses "C") high to the 3rd is received -- this -- it is characterized by the ratio of high peak intensity (B) becoming the 2nd or less by $2.0 (B/C \leq 2.0)$.

[0010] The hard film covering super-elevated-temperature high-pressure sintered compact of this invention demonstrates the SHINAJI effectiveness that abrasion resistance is also excellent while raising the reinforcement of the hard film itself, and toughness by applying a gaseous-phase method epitaxial growth technique, strengthening orientation of the crystal face in the hard film (200) which becomes by the monolayer of Ti compound layer and a Ti-aluminum content compound layer, or the multilayer, and controlling the distortion in the hard film as much as possible. When an X diffraction is carried out using a copper target from the front face of this hard film, the peak intensity (A) of the crystal face over peak intensity (B) (200) high to the 2nd less than by 8.5 ($A/B < 8.5$) and peak intensity (C) high to the 3rd is received -- this, when the ratio of high peak intensity (B) becomes high the 2nd exceeding 2.0 ($B/C > 2.0$) (200) Since the stacking tendency to the crystal face is weak, the defect in the film and distortion become large and the above-mentioned SHINAJI effectiveness becomes weak, it is determined as the peak height ratio of the above crystal faces. The peak intensity ratio of this crystal face is promotion of much more crystal stacking tendency and control of a defect or distortion will be caused, and adhesion with a base material will be raised, and desirable [consisting of $A/B \geq 9.0$ and $B/C \leq 1.5$ is desirable, and], when becoming by $A/B \geq 10.0$ and $B/C \leq 1.5$ especially.

[0011]

[The mode of implementation of invention] using the super-elevated-temperature high-pressure sintered compact containing the cubic boron nitride and/or the diamond which serve as practical use or common knowledge from the former cuts the base material in the hard film covering super-elevated-temperature high-pressure sintered compact of this invention. With the base material of the super-elevated-temperature high-pressure sintered compact which cubic boron nitride contained, specifically 20 - 98 % of the weight and the remainder the content of cubic boron nitride 4a and 5a of the periodic table, 6a group's metal, the metal of Mn, Fe, nickel, Co, Si, aluminum, and Mg, The cubic boron nitride content

sintered compact which becomes by these alloys, these carbide, the nitride, the oxide, boride, and one or more sorts of reinforcement distribution matter chosen from these mutual solid solutions can be mentioned. Moreover, in the base material of the super-elevated-temperature high-pressure sintered compact which the diamond contained, for example, the diamond content sintered compact which becomes about the content of a diamond by 70 - 99 % of the weight and the reinforcement distribution matter with the above-mentioned remainder can be mentioned. Furthermore, in the base material of the super-elevated-temperature high-pressure sintered compact with which cubic boron nitride and a diamond were intermingled, for example, the sintered compact which becomes about 15 - 80 % of the weight and the content of a diamond in the content of cubic boron nitride by 15 - 80 % of the weight and the reinforcement distribution matter with the above-mentioned remainder can be mentioned.

[0012] Cubic boron nitride among these base materials 40 - 98 % of the weight, The compound boride with which the remainder contains the carbide of Ti, a nitride, carbon nitride, boride, the nitride of aluminum, an oxide, boride, the nitride of Si, carbide, the oxide of Mg, the carbide of W and these mutual solid solutions, Ti, and aluminum and Mg, compound *****, and aluminum, Ti, Co, nickel, Si, In becoming with the super-elevated-temperature high-pressure sintered compact containing these mutual alloys and at least one sort of reinforcement distribution matter chosen from intermetallic compounds The orientation of the hard film covered by the base material front face comes to be [excelling in properties, such as reinforcement of the base material itself, and a high degree of hardness,] easily excellent, (200) -- and (220) (311) it is desirable from the X diffraction peak of the crystal face (200) becoming extremely high to other crystal faces among the crystal faces, and excelling in the adhesion of a base material and the hard film, and the defect in the hard film being controlled. [namely, (111),]

[0013] These base materials are desirable things from frictional resistance becoming low, the dry area of a hard film front face and a *-ed material front face being controlled, and the improvement effectiveness in a life becoming high, when surface precision was made high, and the inclination for the surface precision of the hard film covered by the base material front face to also become high is shown, for example, is used as a cutting tool. The surface precision of a base material has desirable 0.1 micrometers or less at Ra which is the center line average of roughness height in the surface roughness specified to JIS B0601, and, as for more desirable one, Ra consists of 0.05 micrometers or less.

[0014] If the configuration of the coat covered by these base material front faces is concretely divided roughly, when a base material front face will be adjoined and only the direct hard film will be covered, the hard film and other film other than the hard film may be covered by the base material front face. Among these, if the latter coat configuration is explained, the configuration by which sequential covering of the film besides base material-hard film - was carried out, the configuration by which sequential covering of the film-hard film besides base material-hard film - was carried out, and the configuration to which the laminating of the hard film and other film was carried out repeatedly twice or more, respectively can be mentioned. The hard film which adjoins a base material and is covered consists of the cubic crystal structure among these, and crystal orientation by the X diffraction mentioned above is performed.

[0015] When the front face of the hard film which these coat front faces adjoin a base material, and is covered turns into a coat front face as it is, other film may serve as a coat front face. When this coat front face was preferably set to 0.05 micrometers or less and it is used as a cutting tool 0.1 micrometers or less by center line average-of-roughness-height Ra in the surface roughness specified to JIS B0601, from that the damage to *-ed material is eased, that cutting force is eased, and discharge of a chip becoming easy, it becomes long lasting and it is much more desirable thing.

[0016] As this coat configuration, about the fundamental configuration of the hard film, if it explains to a detail still more concretely A base material-TiN layer, a base material-TiC layer, a base material-Ti (N, C) layer, a base material-Ti (N, O) layer, A base material-Ti (C, O) layer, a base material-Ti (N, C, O) layer, a base material-(Ti, aluminum) N layer, A base material-(Ti, aluminum) (N, C) layer, a base material-(Ti, aluminum) (N, O) layer, A base material-TiN layer-(Ti, aluminum) N layer, a base material-Ti (N, C) layer-(Ti, aluminum) N layer, A base material-Ti (N, O) layer-(Ti, aluminum) N

layer, a base material-Ti (C, O) layer-(Ti, aluminum) N layer, a base material-Ti (N, C, O) layer-(Ti, aluminum) N layer, or the hard film that carried out the three or more layer laminating of these can be mentioned as an example of representation.

[0017] moreover, as a coat configuration adapting these hard film 203 layers of base material-TiN layer-aluminum, 203 layers of base material-Ti (N, O) layer-aluminum, 203 layers of base material-(Ti, aluminum) N layer-aluminum, 203 layers of base material-(Ti, aluminum) (N, O) layer-aluminum, 203 layers of base material-TiN layer-(Ti, aluminum) N layer-aluminum, 203 layers of base material-TiN layer-(Ti, aluminum) (N, O) layer-aluminum, 203 layers of base material-TiN layer-columnar crystal Ti (C, N) layer-aluminum, 203 layers of base material-Ti (N, O) layer-columnar crystal Ti (C, N) layer-aluminum, The 203 layer-TiN layer of base material-TiN layer-aluminum, the 203 layer-TiN layer of base material-Ti (N, O) layer-aluminum, The 203 layer-TiN layer of base material-(Ti, aluminum) N layer-aluminum, the 203 layer-TiN layer of base material-(Ti, aluminum) (N, O) layer-aluminum, The 203 layer-TiN layer of base material-TiN layer-(Ti, aluminum) N layer-aluminum, the 203 layer-TiN layer of base material-TiN layer-(Ti, aluminum) (N, O) layer-aluminum, The 203 layer-TiN layer of base material-TiN layer-columnar crystal Ti (C, N) layer-aluminum or the 203 layer-TiN layer of base material-Ti (N, O) layer-columnar crystal Ti (C, N) layer-aluminum can be mentioned as an example of representation.

[0018] In becoming by the monolayer or the multilayer hard film which adjoins a base material among these coat configurations, and is covered It excels in adhesion by being the same crystal structure as the cubic boron nitride and/or the diamond which the hard film contains in the base material, It is desirable from the cubic boron nitride in that the covering process of a coat is simple, becoming compaction of process time amount, that the variation on quality control decreases, and the base material at the time of hard film covering and/or the inverse transformation prevention effectiveness of a diamond being easy. Moreover, when it makes the coat configuration which becomes in the hard film contiguous to a base material, and the layer of the aluminum oxide contiguous to this hard film, or the coat configuration which repeated and carried out the laminating of the layer of the hard film and an aluminum oxide, it is desirable from demonstrating in multiplication the effectiveness by the layer of the aluminum oxide of raising the thermal resistance in an elevated-temperature field, oxidation resistance, and abrasion resistance further with the effectiveness of the hard film which adjoins the base material mentioned above and is covered.

[0019] The hard film contiguous to the base material which becomes indispensable constituting these coats has the case of Ti compound layer which becomes by the monolayer or the multilayer. $Ti(C_x, N_y, O_z)_w$, however x this Ti compound layer The atomic ratio of the carbon (C) element in a nonmetallic element, The atomic ratio of the nitrogen (N) element in a nonmetallic element and z y The atomic ratio of the oxygen (O) element in a nonmetallic element, w expresses the atomic ratio of a nonmetallic element to the titanium (Ti) element which is a metallic element. respectively -- $x+y+z$ -- = -- one -- 0.5 -- >= -- x -- >= -- zero -- one -- >= -- y -- >= -- zero -- five -- 0.5 -- >= -- z -- >= -- zero -- 1.05 -- >= -- w -- >= -- 0.7 -- relation -- it is -- j -- expressing -- having -- Ti -- a compound -- a layer -- becoming -- a case -- **** -- a **** -- hard -- the film -- effectiveness -- easy -- demonstrating -- making -- obtaining -- things -- from -- being desirable -- things -- it is .

[0020] Moreover, the hard film contiguous to a base material has the case of the Ti-aluminum content compound layer which becomes by the monolayer or the multilayer. this Ti-aluminum content compound layer -- $w(C_x(Ti_a, Al_b), N_y, O_z)$ [-- however The atomic ratio of Ti (titanium) element in a metallic element and b a The atomic ratio of aluminum (aluminum) element in a metallic element, The atomic ratio of the carbon (C) element in a nonmetallic element and y x The atomic ratio of the nitrogen (N) element in a nonmetallic element, The atomic ratio j as opposed to / as opposed to / in z / the atomic ratio of the oxygen (O) element in a nonmetallic element / the sum total of a metallic element in w j of a nonmetallic element is expressed. respectively -- $a+b$ -- = -- one -- 0.8 -- >= -- a -- >= -- zero -- four -- $x+y+z$ -- = -- one -- 0.5 -- >= -- x -- >= -- zero -- one -- >= -- y -- >= -- zero -- five -- 0.5 -- >= -- z -- >= -- zero -- 1.05 -- >= -- w -- >= -- 0.7 -- relation -- it is -- j -- expressing -- having -- Ti-aluminum -- content -- a compound -- a layer -- becoming -- a case -- **** -- It is desirable from excelling in

abrasion resistance excelling in the adhesion and adjustment in a field side of a base material, the hard film, and an aluminum oxide with a layer, and hot, and oxidation resistance. Furthermore, the hard film is a desirable thing from consisting of a multilayer which becomes in Ti compound layer and a Ti-aluminum content compound layer, and the configuration of this hard film demonstrating abrasion resistance and oxidation resistance in a larger temperature field with the same effectiveness as ****.

[0021] When the Ti-aluminum content compound layer exists in all hard film including the hard film contiguous to these base materials aluminum element content in a Ti-aluminum content compound layer is decreasing toward a base material side from the front-face side of a Ti-aluminum content compound layer. It is desirable from excelling in the reinforcement of that the adhesion of a base material and the hard film is excellent, and the hard film itself, and toughness, if it is made the so-called hard film of an inclination presentation, and the oxidation resistance of that a defect, distortion, and residual stress decrease and a hard film front face, abrasion resistance, and corrosion resistance being excellent. Though reduction of aluminum element at this time has increase and decrease in micro stair-like and in the shape of [of a saw] a cutting edge, when it decreases gradually in macro, the case where it is decreasing continuously parabolic and in the shape of a straight line is sufficient as it.

[0022] the hard film which becomes in these Ti compound layers and/or a Ti-aluminum content compound layer, especially the hard film contiguous to a base material -- the inside of this hard film -- 4a and 5a of the periodic table, 6a group metal, an iron-group metal, and aluminum, Si, Mn and Mg -- minute amount content of the alloy of these or at least one sort of hard film strengthening matter in an intermetallic compound may be carried out When becoming by at least one sort chosen among these hard film strengthening matter from the metals of nickel, Co, W, Mo, aluminum, and Ti, these mutual alloys, and these intermetallic compounds, it is desirable from a defect and distortion being eased, and the effectiveness of the above-mentioned hard film improving further, and becoming remarkable. Especially in the case of the element contained in the base material, and the base material which specifically becomes with the above-mentioned cubic boron nitride content sintered compact, when it consists of an element which constitutes the reinforcement distribution matter, it is a desirable thing from improving one layer of effectiveness nearby of the adhesion of a base material and the hard film with the effectiveness of the above-mentioned hard film.

[0023] Specifically as a content of these hard film strengthening matter, it is desirable from the synergistic effect of excelling also in abrasion resistance being demonstrated while excelling in the collapse-proof reinforcement of the from both [a perpendicular direction and / horizontal] a front face, and compressive strength-proof, when it contains below 1 volume % preferably below 3 volume % to the sum total of the hard film and the hard film strengthening matter. [of the compound hard film] [both]

[0024] Moreover, when the columnar crystal which grew perpendicularly in the shape of a column to the base material front face as structure of the hard film itself is contained, it is desirable from the collapse-proof reinforcement from the front face of the compound hard film improving, and excelling in peeling resistance and minute-proof chipping nature. Specifically, the hard film containing this columnar crystal can illustrate the case where minute amount content of the hard film strengthening matter mentioned above in each of these granular crystals and columnar crystals is carried out, when the whole hard film becomes in the layer of a columnar crystal, it becomes in the intermingled layer of a granular crystal and a columnar crystal and it becomes in the laminating of the layer of a granular crystal, and the layer of a columnar crystal.

[0025] The hard film covering super-elevated-temperature high-pressure sintering object of this invention which becomes in various kinds of above modes can be used for various kinds of applications, and, specifically, can be used as tools for antifriction, such as cutting cutting edges, such as a slitting machine, and a decision cutting edge, from mold tools, such as a lathe-turning tool, a milling cutter tool, a drill, a cutting tool represented by the end mill, and a dice. Among these, the hard film covering super-elevated-temperature high-pressure sintering object of this invention is a desirable thing from demonstrating the property of a base material and the hard film the optimal, when using it as cutting tools, such as rotation cutting tools, such as a cutting tool with which temperature, friction, a thermal

shock, a compression impact, etc. serve as a severe condition most in micro especially a drill, and an end mill, and a throwaway tip. In using this hard film covering super-elevated-temperature high-pressure sintering object as a cutting tool, there is a problem of the cutting edge relevant to a nick, a chipping, etc. besides the problem of the profile irregularity in the front face mentioned above. The problem of this cutting edge is desirable [it is also desirable to solve with honing configurations, such as beveling and/or R form, and] from excelling in the peeling resistance of a coat, and the minute chipping nature of a cutting edge, when coating thickness is decreasing toward a cutting blade edge line part especially.

[0026] Moreover, the film thickness of each class which constitutes a coat is that it is desirable to set the total film thickness of a coat to 1-20 micrometers by the configuration of an application, a configuration, and a coat in choosing is desirable and using it for the severest cutting tool etc. Moreover, although it is also possible to thicken film thickness of a coat further when using it for a wear-proof tool etc., it is that it is desirable to make it above-mentioned total film thickness extent from a covering process serving as long duration etc. When becoming with stoichiometric composition, the case where it becomes with non-stoichiometric composition is sufficient as the reinforcement distribution matter which contains at first the hard film explained in full detail above in a base material, and it consists of non-stoichiometric composition substantially in many cases.

[0027] The hard film covering super-elevated-temperature high-pressure sintering object of this this invention The super-elevated-temperature high-pressure sintered compact represented by the cubic boron nitride system sintered compact marketed from the former and the diamond system sintered compact or the super-elevated-temperature high-pressure sintered compact of cubic boron nitride content mentioned above is used as a base material. After grinding the front face of this base material if needed and performing ultrasonic cleaning, organic solvent washing, etc., a coat can be covered with the PVD, CVD method, or plasma-CVD method currently performed from the former on a base material, and it can produce. When especially the hard film that adjoins a base material front face and is covered is produced by the following PVD, it is a desirable thing from the property and adhesion of that the gaseous-phase epitaxial crystal growth and crystal orientation of that improvement in a plasma consistency and improvement in ionization efficiency are attained and the hard film itself become easy and the hard film being more excellent.

[0028] When the important description is concretely explained in full detail as an approach for covering the hard film which adjoins a base material front face and is covered, the front face of a base material At least one sort of mechanical processes in the blasting processing currently performed from the former, shot-peening processing, polish processing, and barrel processing. At least one sort of chemical preparation in washing by the surface corrosion by the electrolytic etching by the acid or alkaline electrolytic solution, the acid solution, and the alkali solution or water, and the organic solution. When processing chosen from coincidence or the art performed separately in this mechanical process and chemical preparation is performed, it is desirable from the ability to control [that the defect on the front face of a base material is removable, that the adhesion of the hard film can be raised, that the distortion in the film can be controlled, and] the defect in the film. Moreover, a base material is that it is desirable to add such mechanical treatment and/or chemical preparation, and heat treatment by low temperature, and to also heighten above-mentioned effectiveness.

[0029] As for the covering approach of the hard film, it is desirable to carry out by the PVD represented by a sputtering technique and the ion plating method, and it is an especially desirable thing among these from adjustment of the hard film being easy when it carries out by the magnetron sputtering method or the arc-plasma ion plating method. When arranging a base material in the reaction container of an ion plating system, specifically carrying out bombardment processing of the base material front face and bombardment processing by the ion of a metallic element and/or a nitrogen element or bombardment processing by both metallic element ion and nonmetallic element ion is performed, above-mentioned effectiveness will be heightened and it is desirable.

[0030] The still more concrete covering approach of the hard film needs to attach importance to the effect of equipment itself, such as structure of a reaction container, and adjustment of the plasma. For example, the thing for which the equipment made to generate acceleration of ion and the plasma and the

equipment which can adjust the plasma by the field are used with the power source (the pulse-like high voltage and a RF are added depending on the case) of the high voltage, In addition, the thing for which it is necessary to consider about arrangement of the ambient pressure force in a reaction container, temperature, an arc discharge current, electrical potential difference, base material bias voltage, and a sample etc., and especially an arc discharge electrical potential difference is made high to the conventional conditions among these, Rotation, vertical movement, etc. of making base material bias voltage high, taking in the gaseous-phase epitaxial crystal growth approach currently performed from the former, and a sample serve as important requirements.

[0031]

[Embodiment of the Invention]

[Operation trial 1] An operation trial explains the operation gestalt of this invention explained in full detail above as a still more concrete example of representation. First, the cemented carbide of SNGN120408 configuration by the ISO standard produced through each process of the conventional combination, mixing, shaping, and sintering was made into base metal, the base material of the super-elevated-temperature high-pressure sintered compact of cubic boron nitride content which becomes the corner section used as the edge of a blade of this cemented carbide base metal of the presentation component shown in Table 1 was joined, and the compound sintered compact was obtained. This compound sintered compact joins directly the cubic boron nitride content presentation component shown in cemented carbide base metal and Table 1 by pressure 5.5GPa and super-elevated-temperature high-pressure sintering of temperature 1773K. Moreover, the case where a super-elevated-temperature high-pressure sintered compact is joined to cemented carbide base metal by silver low attachment is sufficient as a compound sintered compact. The hard film was covered with the arc ion plating system, after having performed the grinding process for the vertical side and peripheral face of these compound sintered compacts by the diamond wheel of 270#, performing -25 degreeex0.10mm honing to the edge-of-a-blade section by the 400# diamond wheel and performing wet blasting processing, washing processing, and desiccation processing for a front face further.

[0032] The art covered the hard film, after carrying out bombardment processing of each concurrent-sintering body surface in a reaction container (especially base material front face). Bombardment processing set [the temperature of a vacuum and a base material] bias voltage of 60-80A, and a base material to -400--700V for 823-873K, and an arc current, and performed the ambient atmosphere in a reaction container by Ar-N₂ gas bombardment. Ti metal (for Ti compound layers) or the Ti-aluminum alloy (for Ti-aluminum content compound layers) performed 150 - 450SCCM and an evaporation source, -100--200V performed [arc voltage / 150-350V, and an arc current] 773-923K, and base material bias voltage of a compound sintered compact for 150-250A, and the base material temperature of a compound sintered compact, and covering of the hard film obtained this invention article 1-10 shown in Table 2 for the quantity of gas flow in a reaction container.

[0033] The ambient atmosphere in a reaction container at the time of hard film covering at this time The case where the cases of a TiN layer and (Ti, aluminum) N layer are N₂ gas presentation and Ti (C, N) layer An N₂-C₂H₄ gas presentation, The case where the cases of a TiC layer are CH₄ gas presentation and Ti (N, O) layer An N₂-CO-CO₂ gas presentation, It carried out by the N₂-CH₄-CO gas presentation, and carried out by the case of Ti (C, N, O) layer having changed from the alloy with many Ti elements to the evaporation source of this invention article 4 to the alloy with many aluminum elements, and this invention article 1-10 with which the hard film shown in Table 2 was covered was obtained.

[0034] The hard film shown in Table 3, respectively was covered on the front face of the isomorphism-like compound sintered compact which carried out silver low attachment of the super-elevated-temperature high-pressure sintered compact of the cubic boron nitride content marketed, and obtained it to cemented carbide as a comparison, and the comparison article 1-5 was obtained. The front face of the compound sintered compact of use in the above-mentioned this invention article 1-10 was [the front face of the compound sintered compact of use in the comparison article 1-5 of the surface roughness of a compound sintered compact] Ra=0.1-0.05micrometer to Ra=0.01-0.005micrometer. Except for wet

blasting processing, others processed almost similarly the surface preparation of the compound sintered compact in the comparison article 1-5 among the surface preparation of this invention article mentioned above. Moreover, Ar gas performed bombardment processing in this comparison article 1-5, and covering of the hard film processed arc voltage almost similarly among the processing conditions of the hard film of this invention article mentioned above except having set 150-200A, and base material bias voltage to -80-200V for 10-50V, and an arc current.

[0035] In this way, about each of the obtained this invention article 1-10 and the comparison article 1-5, using Cu target, the range of 2θ =30-80 degree was diffracted whenever [angle-of-diffraction] from the hard film front face, and each peak intensity of the crystal face (111) of the hard film, the crystal face (200), the crystal face (220), and the crystal face (311) was measured with X-ray diffractometer. The axis of abscissa measured the height of a peak with the respectively high reinforcement to the 1st - 3rd per nm among the X diffraction patterns as which an axis of ordinate expresses peak intensity in whenever [angle-of-diffraction (2θ)], and, as for measurement of peak intensity, showed the result in Tables 4 and 5. Although great difference [the peak high to the 1st in this invention article 1-10 of Table 4 was the crystal face (200) and / the 2nd peak high to the 3rd / the crystal face (111), the crystal face (220), and the crystal face (311)] hardly, the crystal face (111) and (311) the crystal face were measured. The comparison article 1-5 of Table 5 measured the crystal face, the crystal face (111), and (311) the crystal face similarly (200). It checked that the hard film of this invention article 1-10 at this time consisted of the cubic crystal structure.

[0036] About such this invention article 1-10 and the comparison article 1-5, the condition of the hard film was mainly investigated using a scanning electron microscope, a metaloscope, EDS equipment, the Vickers hardness tester, and the scratch testing machine that scratches and is equivalent to a hardness tester. The film thickness of the hard film was shown in Tables 2 and 3 among these results of an investigation. The scratch reinforcement measured as peeling resistance of the hard film showed each result in Table 6. In addition, the oxygen content in the hard membrane layer of the hard film which oxygen contained among the hard film of this invention article 1-10 was 0.2 atomic ratios to the whole nonmetallic element. (Ti, aluminum) The hard membrane layer of N was Ti:aluminum=1:1 mostly, among these this invention article 4 was N (Ti, aluminum) hard membrane layer of the inclination presentation which aluminum element increased gradually toward the film front face from the base material side. Moreover, the hard membrane layer of Ti (C, N) in this invention article 5 and 10 consisted of a columnar crystal crystal.

[0037] Subsequently, the following cutting conditions performed the dry type continuation cutting trial using this invention article 1-10 and the comparison article 1-5. cutting conditions -- 500 m/min and delivery carried [0.3mm and a tool configuration] out to 0.1 mm/rev, and slitting carried [**-ed material / FCD70 and cutting speed] out to SNGN120408 more. When the chipping of a cutting edge and an enveloping layer exfoliated, the time of the amount of average flank wear amounting to 0.2mm was made into the tool life, and the result of a cutting trial found each cutting time at that time, set the sample of the shortest life to 1, and wrote it together to Table 6 as a life ratio to the sample of the shortest life.

[0038]

[Table 1]

試料番号	超高温高圧窒化体の組成成分 (配合時)	体積%
基材 1	88CBN-1A1-TiN	
基材 2	95CBN-1A1-2A1 ₂ O ₃ -2TiN	
基材 3	90CBN-2A1-2B-2Mg-2A1 ₂ O ₃ -2TiN	
基材 4	80CBN-2A1-10A1 ₂ O ₃ -5TiN-3Ti(C,N)	
基材 5	75CBN-2A1-2B-2Mg-2Si-2Ti-15A1 ₂ O ₃ -5TiN	
基材 6	60CBN-10A1-25A1 ₂ O ₃ -5(Ti,Zr)N	
基材 7	40CBN-10A1-35A1 ₂ O ₃ -5(W,Ta)C-10TiN	
基材 8	25CBN-25A1 ₂ O ₃ -10WC-16Ti(C,N)-10A1-10Ti-2Co-8Mg	

[0039]

[Table 2]

試料番号		被膜の膜厚さ(μm)と材質
本発明品	基材番号	被膜組成
1	基材1	5TiN
2	基材2	6(Ti,Al)N
3	基材3	2Ti(C,N)-4(Ti,Al)N
4	基材4	2TiN-5(Ti,Al)N
5	基材5	2TiN-4Ti(C,N)-5(Ti,Al)N-1TiN
6	基材6	2Ti(C,N)-4Ti(N,O)
7	基材7	2TiC-4Ti(C,N,O)
8	基材8	3TiN-5(Ti,Al)N-1TiN
9	基材3	2TiN-2Ti(N,O)-1TiN
10	基材3	2TiN-2Ti(C,N)-1TiN

[0040]

[Table 3]

試料番号	被膜の膜厚さ(μm)と材質
比較品1	5TiN
比較品2	5(Ti,Al)N
比較品3	2Ti(C,N)-4(Ti,Al)N
比較品4	2TiN-4Ti(N,O)
比較品5	2TiN-2Ti(C,N)

[0041]

[Table 4]

試料番号	被膜の各結晶面強度			被膜の結晶面強度比	
	第1番目(A)	第2番目(B)	第3番目(C)	A/B	B/C
1	70.0	6.5	6.0	10.8	1.1
2	59.0	4.0	3.5	13.3	1.1
3	48.5	4.5	4.0	10.8	1.1
4	45.5	4.0	3.5	11.4	1.1
5	75.0	5.0	4.0	15.0	1.5
6	63.5	7.0	5.0	9.1	1.4
7	67.0	7.0	6.0	9.6	1.2
8	46.0	4.0	3.5	11.5	1.1
9	45.0	3.0	3.0	15.0	1.0
10	47.5	3.0	2.0	15.8	1.6

[0042]

[Table 5]

試料番号	被膜の各結晶面強度			被膜の結晶面強度比	
	(200)面(A)	(111)面(B)	($\bar{2}$ 11)面(C)	A/B	B/C
1	69.0	21.0	15.0	3.3	1.4
2	69.0	13.0	2.0	4.5	6.5
3	60.0	C=8.0	B=29.0	2.5	3.5
4	32.0	53.0	5.0	0.6	10.6
5	15.0	85.0	8.0	0.2	10.6

[0043]

[Table 6]

試料番号	スクラッチ荷重(N)	切削試験での寿命比
本発明品	1 140	2.2
	2 180	3.8
	3 180	4.3
	4 140	3.9
	5 160	4.7
	6 140	2.1
	7 180	2.3
	8 140	5.2
	9 150	2.5
	10 140	2.6
比較品	1 80	1.0
	2 60	1.4
	3 50	1.6
	4 60	1.1
	5 50	1.2

[0044]

[Operation trial 2] Using the comparison article 1-5 shown in this invention article 1, 2, 3, 4, and 10 and Table 3 having shown in Table 2 of the operation trial 1, further, as other film, the film of aluminum₂O₃ and TiN was covered with the approach from the former, and the comparison article 6-10 shown in this invention article 11-15 and Table 8 having shown in Table 7, respectively was obtained on each hard film front face. In this way, about this invention article 11-15 and the comparison article 6-10 which were obtained, the hard film and other film were investigated like the operation trial 1, it asked for the scratch reinforcement from a coat front face, and the result was shown in Table 9. Moreover, about this invention article 11-15 and the comparison article 6-10, the cutting trial was performed like the cutting conditions of the operation trial 1, and it asked for each life ratio to the comparison article 1, and wrote together to Table 9.

[0045]

[Table 7]

試料番号	被膜の膜厚さ(μm)と材質		
	基材番号	硬質膜	その他の膜
11	基材1	5TiN	2Al ₂ O ₃ -1TiN
12	基材2	5(Ti,Al)N	4Al ₂ O ₃ -1TiN
13	基材3	2Ti(C,N)-4(Ti,Al)N	2Al ₂ O ₃ -1TiN
14	基材4	2TiN-6(Ti,Al)N	2Al ₂ O ₃ -1TiN
15	基材5	2TiN-2Ti(C,N)-1TiN	2Al ₂ O ₃ -1TiN

[0046]

[Table 8]

試料番号	被膜の膜厚さ(μm)と材質	
	硬質膜	その他の膜
比較品6	5TiN	2Al ₂ O ₃ -1TiN
比較品7	5(Ti,Al)N	2Al ₂ O ₃ -1TiN
比較品8	2Ti(C,N)-4(Ti,Al)N	2Al ₂ O ₃ -1TiN
比較品9	2TiN-4Ti(N,O)	2Al ₂ O ₃ -1TiN
比較品10	2TiN-2Ti(C,N)	2Al ₂ O ₃ -1TiN

[0047]

[Table 9]

試料番号	スクラッチ荷重(N)	切削試験での寿命比	
本発明品	11	180	4.6
	12	160	6.4
	13	170	7.5
	14	160	6.7
	15	180	6.0
比較品	6	100	1.5
	7	110	1.8
	8	105	1.9
	9	90	1.7
	10	110	1.6

[0048]

[Operation trial 3] The compound sintered compact this invention article 16 - for 20 was obtained almost similarly except having considered as the presentation component which showed the base material in Table 10 among the compound sintered compacts used for this invention article of the operation trial 1. On the front face of these compound sintered compacts, the hard film and other film were covered like the operation trials 1 and 2, and this invention article 16-20 shown in Table 11 was obtained. About such this invention article 16-20, like the operation trial 1, it asked for the crystal-face peak height ratio by the X diffraction in a hard film front face, and the result was shown in Table 12. Moreover, about this invention article 16-20, almost like the operation trials 1 and 2, it asked for the scratch reinforcement from the hard film or a coat front face, and the result was shown in Table 13. Next, using this invention article 16-20 and the comparison article 1 in the operation trial 1, 300 m/min and delivery performed 0.1 mm/rev by the cutting conditions of SNGN120408, 0.2mm and a tool configuration performed [an aluminum-Si alloy and cutting speed / slitting] the dry type lathe-turning trial, and **ed material asked for each life ratio to the comparison article 1, and wrote together the result to Table 13. this invention article 18 and 19 at this time performs a brush honing process with diamond powder and a brush so that the film thickness of a coat may decrease toward the ridgeline section. Moreover, Co and/or nickel of ultralow volume contained in the hard film of this invention article 16-20.

[0049]

[Table 10]

試料番号	焼結体の組成成分 (配合時)	体積%
基材 9	98DIA-2Co	
基材 10	98DIA-2Co-3Ni	
基材 11	80CBN-80DIA-2Al-2Co-1Ni-8TiN	
基材 12	30CBN-60DIA-2Al-4Co-2Ni-2TiN	
基材 13	45CBN-45DIA-2Al-2B-2Co-2Ni-2Mg	

[0050]

[Table 11]

試料番号		被膜の膜厚さ(μm)と材質	
本発明品	基材番号	硬質膜	その他の膜
16	基材 9	8TiN	なし
17	基材 10	5(Ti,Al)N	なし
18	基材 11	2Ti(C,N)-4(Ti,Al)N	なし
19	基材 12	2TiN-1Ti(N,O)	3Al ₂ O ₃ -1TiN
20	基材 13	2TiN-4Ti(C,N)-1Ti(N,O)	3Al ₂ O ₃ -1TiN

[0051]

[Table 12]

試料 番号	硬質膜の各結晶面強度			硬質膜の結晶面強度比		
	第1番目(A)	第2番目(B)	第3番目(C)	A/B	B/C	
本 発 明 品	16	68.0	4.0	3.5	17.0	1.1
	17	55.0	3.0	3.0	18.3	1.0
	18	51.5	3.0	2.5	17.1	1.2
	19	65.0	5.5	5.0	11.8	1.1
	20	57.0	4.5	4.0	12.7	1.1

[0052]

[Table 13]

試料番号	スクラッチ荷重(N)	切削試験での寿命比
本	16	2.0
発	17	3.5
明	18	5.5
品	19	6.0
	20	4.7

[0053]

[Effect of the Invention] The hard film covering super-elevated-temperature high-pressure sintered compact of this invention by consideration by the crystal structure of a base material and the hard film, and consideration by the process The hard film by the crystal growth and crystal orientation which were approximated to gaseous-phase method epitaxial is covered, It is [that distortion by the hard film itself and a defect are controlled,] the hard film of a fine crystal, It contrasts with the hard film covering sintered compact which separated from a conventional hard film covering sintered compact or conventional this invention from it being the hard film with which hard film strengthening matter, such as a columnar crystal crystal and/or a metal of a minute amount, was contained depending on the case. The adhesion and peeling resistance of a base material, the hard film and the hard film, other film, etc. are very excellent, The high toughness, the high intensity, the thermal resistance, the thermal shock resistance, the oxidation resistance, and abrasion resistance of the compound hard film itself are excellent, As the result, for example, the thing for which the high toughness to which importance is attached as a cutting tool, abrasion resistance, thermal shock resistance, defect resistance, oxidation resistance, and joining-proof nature improve notably, and reinforcement is attained when it is used as a cutting tool, There is remarkable effectiveness that efficient-ization in cutting being attained and variation are small stable.

[Translation done.]

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1. This document has been translated by computer. So the translation may not reflect the original precisely.
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3. In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1] The coat is covered by the front face of the base material which becomes with the super-elevated-temperature high-pressure sintered compact containing cubic boron nitride and/or a diamond. This coat Ti compound layer which becomes by the carbide of titanium, a nitride, carbon nitride, the carbonation object, the nitric oxide, and the charcoal nitric oxide, And the compound nitride containing titanium and aluminum, compound carbide, compound carbonitride, It has the hard film which becomes by one sort of monolayers or two or more sorts of multilayers which were chosen from the Ti-aluminum content compound layers which become by the compound nitric oxide, the compound carbonation object, and the compound charcoal nitric oxide. this hard film -- from the cubic crystal structure -- becoming -- the front face of this hard film to a copper target -- using -- (111) of this hard film, and (200) -- when the X diffraction of the range where the crystal face is displayed is carried out, and (220) (311) The crystal face (200) shows high peak intensity (it expresses "A") to the 1st in an X diffraction peak. The ratio of high peak intensity becomes the 1st or more from 8.5 ($A/B \geq 8.5$). peak intensity (it expresses "B") high to the 2nd is received -- this -- and peak intensity (it expresses "C") high to the 3rd is received -- this -- the hard film covering super-elevated-temperature high-pressure sintered compact with which the ratio of high peak intensity (B) becomes the 2nd or less by 2.0 ($B/C \leq 2.0$).

[Claim 2] The above-mentioned base material cubic boron nitride 40 - 98 % of the weight, The compound boride with which the remainder contains the carbide of Ti, a nitride, carbon nitride, boride, the nitride of aluminum, an oxide, boride, the nitride of Si, carbide, the oxide of Mg, the carbide of W and these mutual solid solutions, Ti, and aluminum and Mg, compound *****, and aluminum, Ti, Co, nickel, Si, These mutual alloys, the hard film covering super-elevated-temperature high-pressure sintered compact containing at least one sort of reinforcement distribution matter chosen from intermetallic compounds according to claim 1.

[Claim 3] The above-mentioned base material is a hard film covering super-elevated-temperature high-pressure sintered compact according to claim 1 or 2 with which the surface roughness of this base material consists of 0.1 micrometers or less by the average surface roughness by Ra of JIS.

[Claim 4] The above-mentioned coat is a hard film covering super-elevated-temperature high-pressure sintered compact given in any 1 term of claims 1-3 which becomes in the laminating containing the layer of the aluminum oxide which adjoined the above-mentioned hard film and this hard film, and was covered.

[Claim 5] The above-mentioned coat is a hard film covering super-elevated-temperature high-pressure sintered compact given in any 1 term of claims 1-4 which the surface roughness of this coat becomes from 0.1 micrometers or less by the average surface roughness by Ra of JIS.

[Claim 6] The above-mentioned hard film is a hard film covering super-elevated-temperature high-pressure sintered compact given in any 1 term of claims 1-5 in which the columnar crystal which comes to be perpendicularly pillar-shaped is contained to the front face of the above-mentioned base material.

[Claim 7] The above-mentioned hard film is a hard film covering super-elevated-temperature high-pressure sintered compact given in any 1 term of claims 1-6 which adjoin the above-mentioned base

material and are covered.

[Claim 8] The above-mentioned hard film which adjoins the above-mentioned base material and is covered is a hard film covering super-elevated-temperature high-pressure sintered compact according to claim 7 which becomes in at least one sort of Ti compound layers in the carbide of titanium, a nitride, carbon nitride, a carbonation object, a nitric oxide, and a charcoal nitric oxide.

[Claim 9] Ti compound layer as which the above-mentioned Ti compound layer is expressed in $Ti(C_x, N_y, O_z)_w$. The atomic ratio of the carbon (C) element in a nonmetallic element and y [, however x The atomic ratio of the nitrogen (N) element in a nonmetallic element, The atomic ratio of a nonmetallic element to the titanium (Ti) element whose z is the atomic ratio of the oxygen (O) element in a nonmetallic element and whose w is a metallic element is expressed. respectively -- $x+y+z$ -- one -- 0.5 -- $x >=$ -- zero -- one -- $y >=$ -- zero -- five -- 0.5 -- $z >=$ -- zero -- 1.05 -- $w >=$ -- 0.7 -- relation -- it is --] -- containing -- being according to claim 8 -- hard -- the film -- covering -- super- -- an elevated temperature -- high pressure -- a sintered compact .

[Claim 10] The above-mentioned hard film which adjoins the above-mentioned base material and is covered is a hard film covering super-elevated-temperature high-pressure sintered compact according to claim 7 which becomes in at least one sort of Ti-aluminum content compound layers in the compound nitride containing titanium and aluminum, compound carbide, compound carbonitride, a compound nitric oxide, a compound carbonation object, and a compound charcoal nitric oxide.

[Claim 11] Ti-aluminum content compound layer [to which the above-mentioned Ti-aluminum content compound layer is expressed with $w(C_x, Al_b, N_y, O_z)$ -- however The atomic ratio of Ti (titanium) element in a metallic element and b a The atomic ratio of aluminum (aluminum) element in a metallic element, The atomic ratio of the carbon (C) element in a nonmetallic element and y x The atomic ratio of the nitrogen (N) element in a nonmetallic element, The atomic ratio [as opposed to / as opposed to / in z / the atomic ratio of the oxygen (O) element in a nonmetallic element / the sum total of a metallic element in w] of the sum total of a nonmetallic element is expressed. respectively -- $a+b$ -- one -- 0.8 -- $a >=$ -- zero -- four -- $x+y+z$ -- one -- 0.5 -- $x >=$ -- zero -- one -- $y >=$ -- zero -- five -- 0.5 -- $z >=$ -- zero -- 1.05 -- $w >=$ -- 0.7 -- relation -- it is --] -- containing -- being according to claim 10 -- hard -- the film -- covering -- super- -- an elevated temperature -- high pressure -- a sintered compact .

[Claim 12] The above-mentioned hard film is a hard film covering super-elevated-temperature high-pressure sintered compact given in any 1 term of claims 1-6 which are the multilayers more than two-layer [of the above-mentioned Ti compound layer and the above-mentioned Ti-aluminum content compound layer] .

[Claim 13] The above-mentioned hard film is a hard film covering super-elevated-temperature high-pressure sintered compact given in any 1 term of claims 10-12 which aluminum element content in the above-mentioned Ti-aluminum content compound layer becomes from the front face of this Ti-aluminum content compound layer by the inclination presentation which decreased toward the above-mentioned base material side.

[Claim 14] The above-mentioned hard film which adjoins the above-mentioned base material and is covered is a hard film covering super-elevated-temperature high-pressure sintered compact given in any 1 term of claims 7-13 which at least one sort of hard film strengthening matter chosen into this hard film from the metals of nickel, Co, W, Mo, aluminum, and Ti, these mutual alloys, and these intermetallic compounds contains.

[Claim 15] A hard film covering super-elevated-temperature high-pressure sintered compact given in any 1 term of above-mentioned claims 1-14 is a hard film covering super-elevated-temperature high-pressure sintered compact used as a cutting tool.

[Claim 16] The above-mentioned cutting tool is a hard film covering super-elevated-temperature high-pressure sintered compact according to claim 15 with which the film thickness of the above-mentioned coat is decreasing toward the ridgeline section.

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(54) 【発明の名称】 硬質膜被覆超高温高压焼結体

(57) 【要約】 (修正有)

【課題】 硬質膜と隣接する物質との密着性等が改善された切削工具等に用いられる硬質膜被覆焼結体の提供。

【解決手段】 立方晶型化珪素及び／又はダイヤモンドを含有する超高温高压焼結体でなる基材の表面に被膜が被覆されており、該被膜はT i 化合物層、ならびにT i - A l 含有化合物層の中から選ばれた1種の単層または2種以上の多層でなる硬質膜を有しており、該硬質膜が立方晶結晶構造からなり、該硬質膜の(111)、(200)、(220)及び(311)の結晶面が表示される範囲をX線回折したときに、X線回折ピークの中で(200)結晶面が第1番目に高いピーク強度(「A」と表す)を示し、第2番目に高いピーク強度(「B」と表す)に対し、A/B≧8.5の関係を有し、かつ第3番目に高いピーク強度(「C」と表す)に対し、B/C≦2.0の関係を有する硬質膜被覆超高温高压焼結体。

【特許請求の範囲】

【請求項1】立方形窒化素および/またはダイヤモンドを含有する超高温高圧焼結体でなる基材の表面に被膜が被覆されており、該被膜は、チタンの炭化物、窒化物、炭窒化物、炭酸化物、窒酸化物、炭酸窒化物でなるTi化合物層、ならびにチタンとアルミニウムとを含む複合窒化物、複合炭化物、複合炭窒化物、複合窒酸化物、複合炭酸窒化物、複合炭酸窒化物でなるTi-Al含有化合物層の中から選ばれた1種の単層または2種以上の多層でなる硬質膜を有しており、該硬質膜が立方形結晶構造からなり、該硬質膜の表面から銅ターゲットを用いて、該硬質膜の(111)、(200)、(220)および(311)の結晶面が表される範囲をX線回折したときに、X線回折ピークの中で(200)結晶面が第1番目に高いピーク強度「A」と表す、第2番目に高いピーク強度「B」と表すに対する該第1番目に高いピーク強度の比が8.5以上(A/B \geq 8.5)からなり、かつ第3番目に高いピーク強度「C」と表すに対する該第2番目に高いピーク強度(B)の比が2.0以下(B/C \leq 2.0)でなる硬質膜被覆超高温高圧焼結体。

【請求項2】上記基材は、立方形窒化素を40～98重量%と、残部がTiの炭化物、窒化物、炭窒化物、碳化物、Alの炭化物、酸化物、硼化物、Siの窒化物、炭化物、Mgの酸化物、Wの炭化物、およびこれらの相互固溶体、TiとAlとMgを含む複合硼化物、複合窒化物、ならびにAl、Ti、C、Co、Ni、Si、これらの相互合金、金属間化合物の中から選ばれた少なくとも1種の補強分散物質とを含有する請求項1に記載の硬質膜被覆超高温高圧焼結体。

【請求項3】上記基材は、該基材の表面粗さがJIS規格のRaによる平均表面粗さで0.1 μ m以下からなる請求項1または2に記載の硬質膜被覆超高温高圧焼結体。

【請求項4】上記被膜は、上記硬質膜と、該硬質膜に隣接して被覆された酸化的アルミニウムの層を含んだ積層でなる請求項1～3のいずれか1項に記載の硬質膜被覆超高温高圧焼結体。

【請求項5】上記被膜は、該被膜の表面粗さがJIS規格のRaによる平均表面粗さで0.1 μ m以下からなる請求項1～4のいずれか1項に記載の硬質膜被覆超高温高圧焼結体。

【請求項6】上記硬質膜は、上記基材の表面に対し、垂直方向に柱状でなる柱状結晶が含まれている請求項1～5のいずれか1項に記載の硬質膜被覆超高温高圧焼結体。

【請求項7】上記硬質膜は、上記基材に隣接して被覆されている請求項1～6のいずれか1項に記載の硬質膜被覆超高温高圧焼結体。

【請求項8】上記基材に隣接して被覆される上記硬質膜

は、チタンの炭化物、窒化物、炭窒化物、炭酸化物、窒酸化物、炭窒酸化物の中の少なくとも1種のTi化合物層でなる請求項7に記載の硬質膜被覆超高温高圧焼結体。

【請求項9】上記Ti化合物層は、Ti(C_xN_yO_z)で表されるTi化合物層、[ただし、xは非金属元素中の炭素(C)元素の原子比、yは非金属元素中の窒素(N)元素の原子比、zは非金属元素中の酸素(O)元素の原子比、wは金属元素であるチタン(Ti)元素に対する非金属元素の原子比を表し、それぞれがx+y+z=1、0.5 \leq x \leq 0.7、1 \geq y \geq 0.5、0.5 \geq z \geq 0.1、0.05 \leq w \leq 0.7の関係にある]を含有する請求項8に記載の硬質膜被覆超高温高圧焼結体。

【請求項10】上記基材に隣接して被覆される上記硬質膜は、チタンとアルミニウムとを含む複合窒化物、複合炭化物、複合炭窒化物、複合窒酸化物、複合炭酸窒化物、複合炭酸窒化物の中の少なくとも1種のTi-Al含有化合物層でなる請求項7に記載の硬質膜被覆超高温高圧焼結体。

【請求項11】上記Ti-Al含有化合物層は、(Ti_aAl_b)(C_xN_yO_z)で表されるTi-Al含有化合物層[ただし、aは金属元素中のTi(チタン)元素の原子比、bは金属元素中のAl(アルミニウム)元素の原子比、xは非金属元素中の炭素(C)元素の原子比、yは非金属元素中の窒素(N)元素の原子比、zは非金属元素中の酸素(O)元素の原子比、wは金属元素の合計に対する非金属元素の合計の原子比を表し、それぞれがa+b=1、0.8 \geq a \geq 0.4、x+y+z=1、0.5 \geq x \leq 0.7、1 \geq y \geq 0.5、0.5 \geq z \geq 0.1、0.05 \leq w \leq 0.7の関係にある]を含有する請求項10に記載の硬質膜被覆超高温高圧焼結体。

【請求項12】上記硬質膜は、上記Ti化合物層と上記Ti-Al含有化合物層との2層以上の多層でなる請求項1～6のいずれか1項に記載の硬質膜被覆超高温高圧焼結体。

【請求項13】上記硬質膜は、上記Ti-Al含有化合物層中のAl元素含有量が該Ti-Al含有化合物層の表面から上記基材側に向かって減少した傾斜組成でなる請求項10～12のいずれか1項に記載の硬質膜被覆超高温高圧焼結体。

【請求項14】上記基材に隣接して被覆される上記硬質膜は、該硬質膜中にNi、Co、W、Mo、Al、Tiの金属、これらの相互合金、これらの金属間化合物の中から選ばれた少なくとも1種の硬質膜強化物質が含有されている請求項7～13のいずれか1項に記載の硬質膜被覆超高温高圧焼結体。

【請求項15】上記請求項1～14のいずれか1項に記載の硬質膜被覆超高温高圧焼結体は、切削工具として用いられる硬質膜被覆超高温高圧焼結体。

【請求項16】上記切削工具は、上記被膜の膜厚さが被

縁部に向かって減少している請求項15に記載の硬質膜被覆超高温高压焼結体。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、立方晶窒化硼素および/またはダイヤモンドを含有する超高温高压焼結体の基材上にT1化合物層および/またはT1-A1含有化合物層の単層または多層に被覆した硬質膜を含む被膜が被覆された硬質膜被覆超高温高压焼結体に関するものである。

【0002】

【従来の技術】従来から超硬度物質であるダイヤモンドおよび/または立方晶窒化硼素の粉末と金属および/またはセラミックスの粉末との混合粉末を超高温高压装置により焼結した超高温高压焼結体が利用されている。この超高温高压焼結体を基材とし、この基材上に、化学蒸着法（以下、「CVD法」という）、物理蒸着法（以下、「PVD法」という）またはプラズマCVD法を利用して硬質膜を被覆した硬質膜被覆焼結体が提案されている。この硬質膜被覆焼結体の代表的なものに、特開昭59-8679号公報、特開昭61-183187号公報、特開平1-96083号公報、特開平1-96084号公報、および特開平7-24606号公報がある。

【0003】また、従来から超硬合金、サーメットの焼結合金またはセラミックス焼結体を基材とし、この基材上に、CVD法、PVD法またはプラズマCVD法を利用して硬質膜を被覆した被覆焼結部材が多様な形態で実用されてきている。これらの被覆焼結部材のうち、硬質膜の結晶構造に注目したものの代表的なものに、特開昭52-28478号公報、特開平8-209335号公報、特開平291353号公報、特開平9-295204号公報、特開平9-300105号公報、特開平9-300106号公報、特開平9-323204号公報、特開平9-323205号公報、特開平10-76407号公報、特開平10-76408号公報、特開平11-176216号公報、特開平11-131214号公報、特開平11-131215号公報、特開平11-131216号公報、および特開平11-131217号公報がある。

【0004】

【発明が解決しようとする課題】従来技術として挙げた引用文献のうち、特開昭59-8679号公報、特開昭61-183187号公報、特開平1-96083号公報、特開平1-96084号公報、および特開平7-24606号公報には、主として立方晶窒化硼素を含有した超高温高压焼結体を基材とし、この基材表面にT1の炭化物、窒化物、炭窒化物および酸化的アルミニウムなどの硬質膜を単層または多層に被覆した硬質膜被覆焼結体が開示されている。これら5件の同公報に開示の硬質膜被覆焼結体は、硬質膜の膜質を主な特徴とする場合、単

層または多層でなる硬質膜の構成を主な特徴とする場合、焼結体の基材組成成分を主な特徴とする場合などがある。これら5件の公報に開示の硬質膜被覆焼結体は、一見、基材自体の優れた効果と硬質膜自体の優れた効果を融合させていると考えられるが、特に基材と硬質膜との適合性について配慮されていないことから、硬質膜の剥離により短寿命になるという問題がある。また、近年のようなエコロジ問題、省資源問題に端を発して、切削油を使用しない切削するドライ切削用工具、被削材の材質変更などを含めた多様化に伴う最適切削工具、さらなる高速切削条件、高負荷切削条件、高能率切削条件などの市場の要求に適する切削工具などに対しては、同5件の公報に開示の硬質膜被覆焼結体は、硬質膜の剥離易さ、または耐熱性、耐熱衝撃性の不足などにより短寿命になる傾向が高いという問題がある。

【0005】その他の引用文献として挙げた特開昭52-28478号公報、特開平8-209335号公報、特開平291353号公報、特開平9-295204号公報、特開平9-300105号公報、特開平9-300106号公報、特開平9-323204号公報、特開平9-323205号公報、特開平10-76407号公報、特開平10-76408号公報、特開平11-176216号公報、特開平11-131214号公報、特開平11-131215号公報、特開平11-131216号公報、および特開平11-131217号公報には、超硬合金、サーメットの焼結合金またはセラミックス焼結体を基材とし、この基材上に、周期律表4a族の炭化物、窒化物、炭窒化物、ならびにチタンとアルミニウムを含む複合窒化物、複合炭化物、複合炭窒化物、複合炭酸化物、複合炭酸化物、複合炭酸化物でなすT1-A1含有化合物の硬質膜が被覆された被覆焼結部材が開示されている。

【0006】これら15件の同公報に開示の被覆焼結部材は、主として基材表面の硬質膜を種々の形態に配向したことを特徴とするものである。これら15件の同公報の中には、硬質膜内の残留圧縮力方を考慮している場合、または硬質膜内の結晶配向を考慮している場合などがあり、その効果として硬質膜内の粒界破壊の抑制、基材と硬質膜との密着性の向上、耐摩耗性の向上、安定した切削加工、または長寿命の達成などが開示されている。しかしながら、これら15件の同公報に開示の被覆焼結部材は、硬質膜に存在する結晶の欠陥および歪みを配慮されていない。特に基材と硬質膜との適合性について配慮されていないことから、基材と硬質膜との密着性および硬質膜に隣接する他の膜との密着性に満足できなく、硬質膜自体の強度、耐摩耗性も満足するまでに至らず、寿命のパラッキが大きく、切削工具として実用したときに前述したような市場の要求に対して、主に硬質膜の剥離の容易さ、または耐熱性、耐熱衝撃性などの不足により短寿命になるという問題がある。

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【0007】本発明は、上述のような問題点を解決したもので、具体的には、主として超高温高圧焼結体の基材と、この基材に隣接して被覆される硬質膜との結晶構造の適合性、硬質膜の結晶の欠陥、歪み、結晶構造および結晶配向を配慮することにより、基材と硬質膜との密着性を極端に高めて、硬質膜の特性のパラツキを抑制し、高靱性、高硬度性、耐摩耗性、耐酸化性、耐熱衝撃性、耐久損傷性、耐溶着性のある硬質膜とし、切削工具としての使用領域を拡大し、被削材との耐溶着性を向上させた硬質膜とすることにより、層長寿命を達成させた硬質膜被覆超高温高圧焼結体の提供を目的とするものである。

【0008】

【課題を解決するための手段】本発明者は、CVD法、PVD法およびプラズマPVD法に関する硬質膜の成膜についての研究、特にPVD法による硬質膜についての研究を長期に亘って行ってきた結果、立方晶窒化硼素および/またはダイヤモンドを含有する超高温高圧焼結体となる基材の表面にTi化合物層および/またはTi-A1含有化合物層でなる硬質膜を被覆させる場合に、最適な硬質膜構成があるという知見を得たものである。この知見を具体的に説明すると、硬質膜の成膜時におけるプラズマ密度の向上およびイオン化効率の向上を行い、さらに気相法エピタキシャル成長させる状態にすると、硬質膜内の歪みが均一に緩和されること、硬質膜の結晶の欠陥が抑制されること、微細結晶の硬質膜が得られること、従来には見られない極端に最適な状態に配向された結晶の硬質膜となることから、硬質膜自体の強度、耐摩耗性、耐酸化および耐熱性を向上させることが可能となり、硬質膜と基材との密着性の向上が顕著になるという第1の知見と、硬質膜の結晶の配向状態は、硬質膜の表面からX線回折した場合には、硬質膜中の他の結晶面に対し(200)結晶面のピーク強度が極端に高くなることにより判断できるとする第2の知見が主なものである。これらの知見に基づいて、本発明を完成するに至ったものである。

【0009】本発明の硬質膜被覆超高温高圧焼結体は、立方晶窒化硼素および/またはダイヤモンドを含有する超高温高圧焼結体となる基材の表面に被膜が被覆されており、該被膜は、窒化硼素の炭化物、窒化物、炭窒化物、炭酸化物、窒化物、炭窒化物等なるTi化合物層、ならびに窒化硼素とアルミニウムを含む複合窒化物、複合炭化物、複合炭窒化物、複合炭酸化物、複合炭酸窒化物等なるTi-A1含有化合物層の中から選ばれた1種の単層または2種以上の多層の硬質膜を有しており、該基材に隣接して被覆される該硬質膜が立方晶結晶構造からなり、該硬質膜の表面から銅ターゲットを用いて、該硬質膜の(111)、(200)、(220)および(311)の結晶面が表示される範囲をX線回折したときに、X線回折ピークの中で(20

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0)結晶面が第1番目に高いピーク強度(「A」と表す)を示し、第2番目に高いピーク強度(「B」と表す)に対する該第1番目に高いピーク強度の比が8.5以上(A/B \geq 8.5)からなり、かつ第3番目に高いピーク強度(「C」と表す)に対する該第2番目に高いピーク強度(B)の比が2.0以下(B/C \leq 2.0)であることを特徴とするものである。

【0010】本発明の硬質膜被覆超高温高圧焼結体は、気相法エピタキシャル成長技術を応用して、Ti化合物層およびTi-A1含有化合物層の単層または多層でなる硬質膜における(200)結晶面の配向を強くし、硬質膜内の歪みを極力抑制することにより、硬質膜自体の強度、靱性を高めると共に、耐摩耗性にも優れるというシナージ効果を発揮させたものである。この硬質膜の表面から銅ターゲットを用いてX線回折したときに、第2番目に高いピーク強度(B)に対する(200)結晶面のピーク強度(A)が8.5未満(A/B<8.5)で、かつ第3番目に高いピーク強度(C)に対する該第2番目に高いピーク強度(B)の比が2.0を超えて高くなる(B/C>2.0)場合には、(200)結晶面への配向性が弱く、膜内の欠陥および歪みが大きくなり、上述のシナージ効果が弱くなることから、上述のような結晶面のピーク高さ比と定めたものである。この結晶面のピーク強度比は、A/B \geq 9.0およびB/C \leq 1.5からなることが好ましく、特にA/B \geq 10.0およびB/C \leq 1.5でなる場合には、より一層の結晶配向性の促進および欠陥や歪みの抑制が図られ、基材との密着性を高めることになり、好ましいことである。

【0011】

【発明の実施の態様】本発明の硬質膜被覆超高温高圧焼結体における基材は、従来から実用または周知となっている立方晶窒化硼素および/またはダイヤモンドを含有した超高温高圧焼結体を用いることができる。具体的には、例えば立方晶窒化硼素の含有した超高温高圧焼結体の基材では、立方晶窒化硼素の含有量を20~98重量%と、残部が周期律表の4a, 5a, 6a族の金属、Mn, Fe, Ni, Co, Si, Al, Mgの金属、これらの合金、これらの炭化物、窒化物、酸化物、硼化物、およびこれらの相互固溶体の中から選ばれた1種以上の補強分散物質とでなる立方晶窒化硼素含有焼結体を挙げることができる。また、例えばダイヤモンドの含有した超高温高圧焼結体の基材では、ダイヤモンドの含有量を70~99重量%と、残部が上述の補強分散物質とでなるダイヤモンド含有焼結体を挙げることができる。さらに、例えば立方晶窒化硼素とダイヤモンドの混在した超高温高圧焼結体の基材では、立方晶窒化硼素の含有量を15~80重量%と、ダイヤモンドの含有量を15~80重量%と、残部が上述の補強分散物質とでなる焼結体を挙げることができる。

【0012】これらの基材のうち、立方晶窒化硼素を4

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0~98重量%と、残部がTiの炭化物、窒化物、炭窒化物、硼化物、Alの窒化物、酸化物、硼化物、Siの窒化物、炭化物、Mgの酸化物、Wの炭化物、およびこれらの相互固溶体、TiとAlとMgを含む複合硼化物、複合窒窒化物、ならびにAl、Ti、Co、Ni、Si、これらの相互合金、金属間化合物の中から選ばれた少なくとも1種の補強分散物質とを含有する超高温高圧焼結体である場合には、基材自体の強度、高硬度などの特性に優れること、基材表面に被覆される硬質膜の配向が容易に優れるようになること、すなわち(111)、(200)、(220)および(311)の結晶面のうち、(200)結晶面のX線回折ピークが他の結晶面に対し、極端に高くなり、基材と硬質膜との密着性に優れること、硬質膜中の欠陥が抑制されることから、好ましいことである。

【0013】これらの基材は、表面精度を高くすると、基材表面に被覆される硬質膜の表面精度も高くなる傾向を示し、例えば、切削工具として使用した場合に摩耗抵抗が低くなって硬質膜表面および被覆材表面の荒れが抑制されて、寿命向上効果が高くなることから好ましいことである。基材の表面精度は、JIS規格B0601に規定されている表面粗さにおける中心線平均粗さであるRaで0.1μm以下が好ましく、より好ましいのはRaが0.05μm以下からなるものである。

【0014】これらの基材表面に被覆される被膜の構成は、具体的に大別すると、基材表面に隣接して直接硬質膜のみが被覆される場合、基材表面に硬質膜と硬質膜以外の他の膜とが被覆される場合がある。このうち、後者の被膜構成について説明すると、基材—硬質膜—他の膜が順次被覆された構成、基材—硬質膜—他の膜—硬質膜が順次被覆された構成、硬質膜と他の膜とがそれぞれ2回以上繰り返して積層された構成を挙げることができる。これらのうち、基材に隣接して被覆される硬質膜が立方晶結晶構造からなり、かつ上述したX線回折による結晶配向が行われているものである。

【0015】これらの被膜表面は、基材に隣接して被覆される硬質膜の表面がそのまま被膜表面となる場合、または他の膜が被膜表面となる場合などがある。この被膜表面は、JIS規格B0601に規定されている表面粗さにおける中心線平均粗さRaで0.1μm以下、好ましくは0.05μm以下とする、切削工具として使用した場合には、被覆材への損傷が緩和され、切削抵抗が緩和され、切削の排屑が容易になることから、より一層の長寿命となり、好ましいことである。

【0016】この被膜構成として、硬質膜の基本的な構成について、さらに具体的に詳細に説明すると、基材—TiN層、基材—TiCN層、基材—Ti(N, C)層、基材—Ti(N, O)層、基材—Ti(C, O)層、基材—Ti(N, C, O)層、基材—Ti(Ti, Al)N層、基材—Ti(Ti, Al)(N, C)層、基材—Ti(Ti, Al)N層、

Al)(N, O)層、基材—TiN層—Ti(Ti, Al)N層、基材—Ti(N, C)層—Ti(Ti, Al)N層、基材—Ti(N, O)層—Ti(Ti, Al)N層、基材—Ti(C, O)層—Ti(Ti, Al)N層、基材—Ti(N, C, O)層—Ti(Ti, Al)N層、またはこれらを3層以上積層した硬質膜を代表例として挙げる事ができる。

【0017】また、これらの硬質膜を応用した被膜構成としては、基材—TiN層—Al₂O₃層、基材—Ti(N, O)層—Al₂O₃層、基材—Ti(Ti, Al)N層—Al₂O₃層、基材—Ti(Ti, Al)N層—Al₂O₃層、基材—TiN層—Ti(Ti, Al)N層—Al₂O₃層、基材—TiN層—Ti(Ti, Al)N層—Al₂O₃層、基材—TiN層—柱状晶Ti(C, N)層—Al₂O₃層、基材—Ti(N, O)層—柱状晶Ti(C, N)層—Al₂O₃層、基材—TiN層—Al₂O₃層—TiN層、基材—Ti(Ti, Al)N層—Al₂O₃層—TiN層、基材—Ti(Ti, Al)N層—Al₂O₃層—TiN層、基材—Ti(Ti, Al)N層—Al₂O₃層—TiN層—柱状晶Ti(C, N)層—Al₂O₃層—TiN層、または基材—Ti(N, O)層—柱状晶Ti(C, N)層—Al₂O₃層—TiN層、を代表例として挙げる事ができる。

【0018】これらの被膜構成のうち、基材に隣接して被覆される単層または多層の硬質膜である場合には、硬質膜が基材に含有されている立方晶窒化硼素および/またはダイヤモンドと同一結晶構造であることにより密着性に優れること、被膜の被覆工程が簡易であること、工程時間の短縮となること、品質管理上のバラツキが少なくなること、および硬質膜被覆時における基材中の立方晶窒化硼素および/またはダイヤモンドの逆変換防止効果が容易であることから、好ましいことである。また、基材に隣接する硬質膜と、この硬質膜に隣接する酸化アルミニウムの層とでなる被膜構成、もしくは硬質膜と酸化アルミニウムの層を繰り返して積層した被膜構成にすると、上述した基材に隣接して被覆される硬質膜の効果とともに高温領域での耐熱性、耐酸化性、耐磨耗性を高めるという酸化アルミニウムの層による効果とを相乗的に発揮させることから、好ましいことである。

【0019】これらの被膜を構成するのに必須となる基材に隣接する硬質膜は、単層または多層であるTi化合物層の場合がある。このTi化合物層は、Ti(C_x, N_y, O_z)。[ただし、xは非金属元素中の炭素(C)元素の原子比、yは非金属元素中の窒素(N)元素の原子比、zは非金属元素中の酸素(O)元素の原子比、wは金属元素であるチタン(Ti)元素に対する非金属元素の原子比を表し、それぞれがx+y+z=1、0.5

$\geq x \geq 0, 1 \leq y \leq 0.5, 0.5 \leq z \leq 0.1, 0.5 \leq w \leq 0.7$ の関係にある]で表されるTi化合物層となる場合には、上述の硬質膜の効果を容易に発揮させることから、好ましいことである。

【0020】また、基材に隣接する硬質膜は、単層または多層でなるTi-A1含有化合物層の場合がある。このTi-A1含有化合物層は、(Ti_a, Al_b)

(C_x, N_y, O_z)・[ただし、aは金属元素中のTi(チタン)元素の原子比、bは金属元素中のAl(アルミニウム)元素の原子比、xは非金属元素中の炭素

(C)元素の原子比、yは非金属元素中の窒素(N)元素の原子比、zは非金属元素中の酸素(O)元素の原子比、wは金属元素の合計に対する非金属元素の原子比を表し、それぞれが $a+b=1, 0.8 \leq a \leq 0.4, x+y+z=1, 0.5 \leq x \leq 0.1, 1 \leq y \leq 0.5, 0.5 \leq z \leq 0.1, 0.5 \leq w \leq 0.7$ の関係にある]

で表されるTi-A1含有化合物層でなる場合には、基材と硬質膜と酸化アルミニウムの層との界面における密着性および整合性に優れること、高温における耐摩耗性、耐酸化性に優れることから、好ましいことである。さらに、硬質膜は、Ti化合物層とTi-A1含有化合物層とでなる多層からなる場合もあり、この硬質膜の構成は、上述と同様の効果とともに、より広い温度領域において耐摩耗性、耐酸化性を発揮させることから、好ましいことである。

【0021】これらの基材に隣接する硬質膜を含めた全ての硬質膜中において、Ti-A1含有化合物層が存在している場合には、Ti-A1含有化合物層中のAl元素含有量がTi-A1含有化合物層の表面面から基材面に向かって減少していること、いわゆる傾斜組成の硬質膜にすると基材と硬質膜との密着性が優れること、硬質膜自体の強度、韌性に優れて、欠陥、歪みおよび残留応力が減少すること、硬質膜表面の耐酸化性、耐摩耗性および耐腐食性が優れることから、好ましいことである。

このときのAl元素の減少は、階段状、ノコギリの刃状にミクロ的に増減があるとしてもマクロ的には段階的に減少する場合、放物線状、直線状に連続的に減少している場合でもよいものである。

【0022】これらのTi化合物層および/またはTi-A1含有化合物層でなる硬質膜、特に基材に隣接する硬質膜は、該硬質膜中に周期律表の4a, 5a, 6a族金属、鉄族金属、Al, Si, Mn, Mgこれらの合金または金属間化合物の中の少なくとも1種の硬質膜強化物質が微量含有されている場合がある。これらの硬質膜強化物質のうち、Ni, Co, W, Mo, Al, Tiの金属、これらの相互合金、これらの金属間化合物の中から選ばれた少なくとも1種でなる場合には、欠陥、歪みが緩和されて前述の硬質膜の効果がより一層向上し、顕著となることから、好ましいことである。特に、基材に含有している元素、具体的には、例えば前述の立方晶型

化元素含有焼結体でなる基材の場合には、補強分散物質を構成する元素からなると、前述の硬質膜の効果とともに、基材と硬質膜との密着性の効果もより一層向上することから、好ましいことである。

【0023】これらの硬質膜強化物質の含有量としては、具体的には、硬質膜と硬質膜強化物質との合計に対し、3体積%以下、好ましくは1体積%以下含有していると、複合硬質膜の表面からの垂直方向および水平方向の両方からの耐圧強度、耐圧強度に優れるとともに、耐摩耗性に優れるという相乗効果が発揮されることから、好ましいことである。

【0024】また、硬質膜自体の構造としては、基材表面に対し垂直方向に柱状に成長した柱状結晶が含まれている場合には、複合硬質膜の表面からの耐圧強度が向上し、耐割離性、耐微小チャIPPING性に優れることから、好ましいことである。この柱状結晶を含む硬質膜は、具体的には、硬質膜全体が柱状結晶の層でなる場合、粒状結晶と柱状結晶との混在した層でなる場合、粒状結晶の層と柱状結晶の層との積層でなる場合、またはこれらの粒状結晶と柱状結晶のそれぞれの中に前述した硬質膜強化物質が微量含有されている場合を例示することができる。

【0025】以上のような各種の様態でなる本発明の硬質膜被覆超高温高圧焼結体は、各種の用途に活用できるものであり、具体的には、例えば旋削工具、フライス工具、ドリル、エンドミルに代表される切削工具、ゲイスなどの型工具からスリッターなどの切削刃、裁断刃などの耐摩耗用工具として実用できるものである。これらのうち、本発明の硬質膜被覆超高温高圧焼結体は、ミクロ的に温度、摩擦、熱衝撃および圧縮衝撃などが最も過酷な条件となる切削工具、特にドリル、エンドミルなどの回転切削工具、スローアウェイチップなどの切削工具として使用する場合には、基材と硬質膜の特性を最適に発揮させることから、好ましいことである。この硬質膜被覆超高温高圧焼結体を切削工具として使用する場合には、前述した表面における面精度の問題他に、刃こぼれ、チャIPPINGなどに関連する切刃の問題がある。この切刃の問題は、例えば面取りおよび/またはR形状のホーニング形状により解決することも好ましく、特に被膜厚さが切刃後縁部に向かって減少していると、被膜の耐割離性、切刃の微小チャIPPING性に優れることから好ましいことである。

【0026】また、被膜を構成する各層の膜厚さは、用途、形状および被膜の構成により、選択することが好ましく、最も過酷な切削工具などに使用するには、被膜の総膜厚さを1~20μmにすることが好ましいことである。また、耐摩耗工具などに使用する場合には、さらに被膜の膜厚さを厚くすることも可能であるが、被覆工程が長時間となることなどから、上述の総膜厚程度にしておくことが好ましいことである。以上に詳述して

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きた硬質膜を初め、基材に含有する補強分散物質は、化学量論組成でなる場合、または非化学量論組成でなる場合でもよく、実質的には非化学量論組成からなっている場合が多いものである。

【0027】この本発明の硬質膜被覆超高温高圧焼結体は、従来から市販されている立方晶型窒素系焼結体、ダイヤモンド系焼結体に代表される超高温高圧焼結体または前述した立方晶型窒素系含有の超高温高圧焼結体を基材とし、この基材の表面を、必要に応じて磨削し、超音波洗浄、有機溶剤洗浄などを行った後に、従来から行われているPVD法、CVD法またはプラズマCVD法により基材上に被覆を被覆して作製することができる。特に、基材表面に隣接して被覆される硬質膜は、以下のPVD法で作製すると、プラズマ密度の向上とイオン化効率の向上が可能となること、硬質膜自体の気相エタキシャル結晶成長および結晶配向が容易となること、硬質膜の特性および密着性がより優れることから、好ましいことである。

【0028】基材表面に隣接して被覆される硬質膜を被覆するための方法として、重要な特徴について具体的に詳述すると、基材の表面は、従来から行われているブラスト処理、ショットピーニング処理、研磨処理、バレル処理の中の少なくとも1種の機械的処理と、酸性もしくはアルカリ性の電解液による電気エッチング、酸溶液、アルカリ溶液による表面腐食、または水、有機溶液による洗浄の中の少なくとも1種の化学的処理と、この機械的処理と化学的処理を同時または別々に行う処理方法とから選択される処理を行うと、基材表面の欠陥を除去でき、硬質膜の密着性を高め得ること、膜内歪みを抑制できること、膜内の欠陥を抑制できることから、好ましいことである。また、基材は、このような機械的処理および/または化学的処理と、低温による熱処理を付加して、上述の効果を高めることも好ましいことである。

【0029】硬質膜の被覆方法は、スパッター法やイオンプレーティング法に代表されるPVD法により行うことが好ましく、これらのうち、マグネトロンスパッター法またはアークプラズマイオンプレーティング法により行うと、硬質膜の調整が容易であることから、特に好ましいことである。具体的には、例えばイオンプレーティング装置の反応容器内に基材を配置し、基材表面をボンバード処理する場合、金属元素および/または窒素元素のイオンによるボンバード処理、もしくは金属元素イオンと非金属元素イオンとの両方によるボンバード処理を施すと、上述の効果を高めることになり、好ましいことである。

【0030】さらに具体的な硬質膜の被覆方法は、反応容器の構造、プラズマの調整など装置自体の影響を重要視する必要がある、例えば高電圧の電源（場合によっては高周波高電圧と高周波を付加）でイオンの加速とプラズマを発生させる装置、磁界によるプラズマの調整可能な装置を使用すること、その他、反応容器内の雰囲気圧力、温度、アーク放電電流、電圧、基材バイアス電圧、試料の配置などについて配慮する必要がある、これらのうち、従来の条件に対し、特にアーク放電電圧を高くすること、基材バイアス電圧を高くすること、従来から行われている気相エタキシャル結晶成長方法を取り入れること、試料の回転および上下動などが重要な要件となる。

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10 【0031】

【発明の実施の形態】

【実施試験1】以上に詳述してきた本発明の実施形態について、さらに具体的な代表例として実施試験の各工程について、説明する。まず、従来の配合、混合、成形、焼結の各工程を経て作製されたISO規格によるSNGN120408形状相当の超硬合金を台金とし、この超硬合金台金の刃先となるコーナ部に表1に示した組成成分でなる立方晶型窒素系含有の超高温高圧焼結体の基材を接合し、複合焼結体を得た。この複合焼結体は、超硬合金台金と表1に示した立方晶型窒素系含有組成成分を圧力5.5 GPa、温度1773 Kの超高温高圧焼結により、直接接合したものである。また、複合焼結体は、超硬合金台金と超高温高圧焼結体を銼口付けにより接合した場合でもよい。これらの複合焼結体の上下面と外周面を270 μmのダイヤモンド磨石で研削加工を施し、刃先部に400 μmダイヤモンド磨石により $25^{\circ} \times 0.10 \text{ mm}$ のホーニング加工を施し、さらに表面を湿式ブラスト処理、洗浄処理および乾燥処理を行った後、アークイオンプレーティング装置により硬質膜を被覆した。

【0032】処理方法は、反応容器内の各複合焼結体表面（特に基材表面）をボンバード処理した後、硬質膜を被覆した。ボンバード処理は、反応容器内の雰囲気圧を真空、基材の温度を823~873 K、アーク電流を60~80 A、基材のバイアス電圧を-400~-700 Vとし、Ar-N₂ガスボンバードにより行った。硬質膜の被覆は、反応容器内のガス流量を150~450 S C M、蒸発源をTi金属（Ti化合物層用）またはTi-Al合金（Ti-Al含有化合物層用）、アーク電圧を150~350 V、アーク電流を150~250 A、複合焼結体の基材温度を773~923 K、複合焼結体の基材バイアス電圧を-100~-200 Vにより行い、表2に示した本発明品1~10を得た。

【0033】このときの硬質膜被覆時の反応容器内雰囲気は、Ti N層および（Ti, Al）N層の場合がN₂ガス組成、Ti（C, N）層の場合がN₂-C₂H₄ガス組成、Ti C層の場合がCH₄ガス組成、Ti（N, O）層の場合がN₂-CO-CO₂ガス組成、Ti（C, N, O）層の場合がN₂-CH₄-COガス組成で行い、本発明品1~10の蒸発源には、Ti元素の多い合金からAl元素の多い合金に切り替えて行い、表2に示した硬質膜

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が被覆された本発明品1~10を得た。

【0034】比較として、市販されている立方晶窒化硼素含有の超高温高圧焼結体を、超硬合金に銀口一付けして得た同形状の複合焼結体の表面にそれぞれ表3に示した硬質膜を被覆して比較品1~5を得た。複合焼結体の表面粗さは、上述の本発明品1~10に使用の複合焼結体の表面が $R_a=0.01\sim0.005\mu\text{m}$ に対し、比較品1~5に使用の複合焼結体の表面が $R_a=0.1\sim0.05\mu\text{m}$ であった。比較品1~5における複合焼結体の表面処理は、上述した本発明品の表面処理のうち、湿式プラスト処理を除いて、その他はほぼ同様に処理した。また、同比較品1~5におけるボンパード処理は、Arガスにて行い、硬質膜の被覆は、上述した本発明品の硬質膜の処理条件のうち、アーク電圧を10~50V、アーク電流を150~200A、基材バイアス電圧を-80~200Vとした以外は、ほぼ同様に処理した。

【0035】こうして得た本発明品1~10および比較品1~5のそれぞれについて、X線回折装置により、Cuターゲットを用いて、硬質膜表面から回折角度 $2\theta=30\sim80$ 度の範囲を回折し、硬質膜の(111)結晶面、(200)結晶面、(220)結晶面、(311)結晶面の各ピーク強度を測定した。ピーク強度の測定は、横軸が回折角(2θ)度で、縦軸がピーク強度を表すX線回折パターンのうち、それぞれ第1番目~第3番目までの強度の高いピークの高さをmm単位で測定し、その結果を表4および5に示した。表4の本発明品1~10における第1番目に高いピークは、(200)結晶面であり、第2番目および第3番目に高いピークは、

(111)結晶面、(220)結晶面、(311)結晶面がほとんど大差ないが、(111)結晶面および(311)結晶面を測定した。表5の比較品1~5は、同様

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*に(200)結晶面、(111)結晶面および(311)結晶面を測定した。このときの本発明品1~10の硬質膜は、立方晶結晶構造からなっていることを確認した。

【0036】これらの本発明品1~10および比較品1~5について、走査型電子顕微鏡、金膜顕微鏡、EDS装置、ピカース硬さ試験機および引張り硬さ試験機に相当するスクラッチ試験機を用いて、主として硬質膜の状態を調査した。これらの調査結果のうち、硬質膜の膜厚さは、表2および3に示した。硬質膜の耐剥離性として測定したスクラッチ強度は、それぞれの結果を表6に示した。なお、本発明品1~10の硬質膜のうち、酸素の含有した硬質膜は、その硬質膜層中の酸素含有量が非金属元素全体に対し、0.2原子比であった。(Ti, Al)Nの硬質膜層は、ほぼTi:Al=1:1であり、このうち本発明品4が基材側から膜表面に向かってAl元素の漸増した傾斜組成の(Ti, Al)N硬質膜層であった。また、本発明品5、10におけるTi(C, N)の硬質膜層は、柱状結晶からなっていた。

【0037】次いで、本発明品1~10および比較品1~5を用いて、以下の切削条件により乾式連続切削試験を行った。切削条件は、被削材がPCD70、切削速度が500m/min、送り量が0.1mm/rev、切り込みが0.3mm、工具形状がSNGN120408、により行った。切削試験の結果は、切刃のチッピング、被覆層の剥離したとき、平均逃げ面摩耗量が0.2mmに達したときを工具寿命とし、そのときのそれぞれの切削時間を求めて、最長寿命の試料を1とし、最長寿命の試料に対する寿命比として、表6に併記した。

【0038】

【表1】

材料番号	超高温高圧焼結体の組成成分(配合時)	体積%
基材1	98CBN-1Al-1TiN	
基材2	95CBN-1Al-2Al ₂ O ₃ -5TiN	
基材3	90CBN-2Al-2B-2Mg-2Al ₂ O ₃ -2TiN	
基材4	80CBN-2Al-10Al ₂ O ₃ -5TiN-5Ti(C,N)	
基材5	70CBN-2Al-2B-2Mg-2B-2Ti-1Al ₂ O ₃ -5TiN	
基材6	60CBN-10Al-26Al ₂ O ₃ -5Ti(C,N)	
基材7	40CBN-10Al-35Al ₂ O ₃ -5Ti(C,N)-10TiN	
基材8	25CBN-25Al ₂ O ₃ -10WC-15Ti(C,N)-10Al-10Ti-2C-3Mg	

【0039】

【表2】

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材料番号	基材番号	硬質膜	硬質膜の膜厚さ(a nm)と材質
1	基材1	5TiN	
2	基材2	5TiAlN	
3	基材3	2Ti(C,N)-4TiAlN	
4	基材4	2TiN-5TiAlN	
5	基材5	2TiN-4Ti(C,N)-5TiAlN-1TiN	
6	基材6	2Ti(C,N)-4TiN(O)	
7	基材7	2TiC-4Ti(C,N,O)	
8	基材8	2TiN-4TiAlN-1TiN	
9	基材9	2TiN-2Ti(C,N)-1TiN	
10	基材3	2TiN-2Ti(C,N)-1TiN	

【表3】

試料番号	被膜の膜厚さ(μm)と材質
比較品1	STiN
比較品2	5(Ti,Al)N
比較品3	2Ti(C,N)-4(Ti,Al)N
比較品4	2TiN-4Ti(N,O)
比較品5	2TiN-2Ti(C,N)

* 【0041】

【表4】

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試料 番号	硬質膜の各結晶面強度			硬質膜の結晶面強度比		
	第1番目(A)	第2番目(B)	第3番目(C)	A/B	B/C	
本 発 明	1	70.0	8.5	6.0	10.8	1.1
	2	89.0	4.0	3.5	13.3	1.1
	3	88.6	4.5	4.0	10.8	1.1
比 較 品	4	45.5	4.0	3.5	11.4	1.1
	5	75.0	3.0	4.0	15.0	1.3
	6	63.5	7.0	5.0	5.1	1.4
	7	67.0	7.5	5.0	9.6	1.2
	8	68.0	4.0	2.5	11.5	1.1
	9	45.0	3.0	3.0	15.0	1.0
	10	47.5	3.0	2.0	15.8	1.5

※ ※ 【表5】

試料 番号	液膜の各結晶面強度			液膜の結晶面強度比		
	(200)面(A)	(111)面(B)	(011)面(C)	A/B	B/C	
比較品	1	89.0	21.0	15.0	3.3	1.4
	2	55.0	12.0	2.0	4.5	6.5
	3	80.0	C=6.0	B=29.0	2.8	3.5
	4	32.0	53.0	5.0	0.6	10.6
	5	15.0	55.0	8.0	0.2	10.6

【0043】

【表6】

試料番号	スクラッチ強度(N)	切剥試験での寿命比
本発明品	1	140
	2	130
	3	130
比較品	4	140
	5	160
	6	140
比較品	7	160
	8	140
	9	150
比較品	10	140
	1	50
	2	60
	3	50
比較品	4	60
	5	50

【0044】

【実施試験2】実施試験1の表2に示した本発明品1、★

試料番号		被膜の膜厚さ(μm)と材質	
本発明品	基材番号	硬質膜	その他の膜
11	基材1	STiN	2AL ₂ O ₃ -TiN
12	基材2	5(Ti,Al)N	4AL ₂ O ₃ -TiN
13	基材3	2Ti(C,N)-4TiAlN	2AL ₂ O ₃ -TiN
14	基材4	2TiN-5(Ti,Al)N	2AL ₂ O ₃ -TiN
15	基材5	2TiN-2Ti(C,N)-TiN	2AL ₂ O ₃ -TiN

【0046】

【表8】

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試料番号	被膜の膜厚さ(μm)と材質	
	硬質膜	その他の膜
比較品6	STiN	2Al ₂ O ₃ -TiN
比較品7	5(Ti,Al)N	2Al ₂ O ₃ -TiN
比較品8	2Ti(C,N)-4(Ti,Al)N	2Al ₂ O ₃ -TiN
比較品9	2TiN-4Ti(N,O)	2Al ₂ O ₃ -TiN
比較品10	2TiN-2Ti(C,N)	2Al ₂ O ₃ -TiN

【0047】

【表9】

試料番号	スクラッチ荷重(N)	切削試験での寿命比
本発明品 11	180	4.6
12	160	6.4
13	170	7.5
14	160	6.7
15	180	5.0
比較品 6	100	1.6
7	110	1.8
8	105	1.9
9	90	1.7
10	110	1.6

【0048】

【実施試験3】実施試験1の本発明品に使用した複合焼結体のうち、基材を表10に示した組成成分とした以外は、ほぼ同様に本発明品16~20用の複合焼結体を得た。これらの複合焼結体の表面に、実施試験1および2と同様に硬質膜、その他の膜を被覆し、表11に示した本発明品16~20を得た。これらの本発明品16~20について、実施試験1と同様に、硬質膜表面におけるX線回折による結晶面ピーク高さ比を求めて、その結果を表12に示した。また、本発明品16~20について、実施試験1および2とはほぼ同様に、硬質膜または被覆膜表面からのスクラッチ強度を求めて、その*

*結果を表13に示した。次に、本発明品16~20と実施試験1における比較品1を用いて、被覆材がAl-Si合金、切削速度が300m/min、送り量が0.1mm/rev、切り込み量が0.2mm、工具形状がSNG N120408、の切削条件により乾式旋削試験を行い、比較品1に対するそれぞれの寿命比を求めて、その結果を表13に併記した。このときの本発明品18および19は、被覆の膜厚さが砥粒部に向かって減少するように、ダイヤモンド粉末とブラシによるブラシホーニング処理を行ったものである。また、本発明品16~20の硬質膜中には、極微量のCoおよび/またはNiが含まれていた。

【0049】

【表10】

試料番号	焼結体の組成成分(配合率)	体積%
基材9	98DIA-2Ca	
基材10	98DIA-2Ca-3Ti	
基材11	90CBN-98DIA-2Al-2Ca-1Ni-1Ti	
基材12	30CBN-98DIA-2Al-4Ca-2Ni-2Ti	
基材13	45CBN-45DIA-2Al-2B-2Ca-2Ni-2Mg	

【0050】

【表11】

試料番号	基材番号	硬質膜の膜厚(μm)と材質	その他の膜
本発明品 16	基材9	STN	なし
17	基材10	98DIA-N	なし
18	基材11	ST(CN)-4(Cr)AlN	なし
19	基材12	STN-1Ti(Cr)O	2Al ₂ O ₃ -1TiN
20	基材13	STN-4Ti(Cr)N-1Ti(Cr)O	2Al ₂ O ₃ -1TiN

【0051】

※ ※ 【表12】

試料番号	硬質膜の各結晶面強度			硬質膜の結晶面強度比	
	第1番目(A)	第2番目(B)	第3番目(C)	A/B	B/C
本発明品 16	68.0	4.0	3.6	17.0	1.1
17	56.0	3.0	3.0	18.3	1.0
18	61.5	3.0	2.6	17.1	1.9
19	65.0	6.5	3.0	11.5	1.1
20	57.0	4.5	4.0	12.7	1.1

【0052】

【表13】

試料番号	スクラッチ荷重(N)	切削試験での寿命比
本発明品 16	170	2.0
17	160	3.5
18	180	5.5
19	160	6.0
20	170	4.7

【0053】

【発明の効果】本発明の硬質膜被覆超高温高压焼結体は、基材と硬質膜との結晶構造による配座と、製法による配座により、気相法エピタキシャルに近似した結晶成長と結晶配向による硬質膜が被覆されていること、硬質膜自体の歪み、欠陥が抑制されていること、微細結晶の*

*硬質膜であること、場合によっては柱状結晶および/または微量の金屈などの硬質膜強化物質が含まれた硬質膜であることから、従来の硬質膜被覆焼結体または本発明から外れた硬質膜被覆焼結体に対して、基材と硬質膜および硬質膜と他の膜などとの密着性および耐剥離性が非常に優れていること、複合硬質膜自体の高靱性、高強度、耐熱性、耐熱衝撃性、耐酸化性および耐摩耗性が優れていること、その結果として例えば切削工具として使用した場合に、切削工具として重要視される高靱性、耐摩耗性、耐熱衝撃性、耐欠損性、耐酸化性および耐溶着性が顕著に向上し、長寿命化が達成されること、切削加工における高効率化が達成されること、バラツキが小さく安定しているという顕著な効果がある。

(11)

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